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THE SULTAN WATER SUPPLY OF EVERETT, WASHINGTON[1]

By Clinton S. Burns[2]

The city of Everett was formerly supplied with water by a private company, which the electors of the place voted in 1915 to buy out, at the same time voting for the construction of works to bring water by gravity from the Sultan River, 25 miles distant. This source of supply had been recommended to the old company in 1911 by its consulting engineer, J. L. Stannard, and was again recommended by the author's firm after an investigation of eleven possible sources, made in 1914 and 1915. The final plans and specifications were filed in April, 1916, and in June of that year the contract for construction was awarded. The contractors began work in that month but in October, 1918, abandoned operations. It will be noted from the dates given that the contract was awarded just prior to the time when labor and industrial work were beginning to feel the hardships of the war in Europe. These war conditions had much to do with the contractors' difficulties, which finally resulted in abandoning the work. On November 10, 1919, the entire line was placed in service, the work having been carried on under the difficulties incident to war-time construction, under the direction of the author's firm, after its abandonment by the contractor.

The supply is developed by means of a timber diversion dam, figure 1, and crib bulkhead. While the work was in progress there were two floods during which the discharge of the river was about 16,000 cubic feet per second. These somewhat damaged the partly completed work. The dam does not contain a fishway, and in place of it the city established a fish hatchery, by agreement with the state authorities.

A two-wire telephone line about 14 miles long has been built to connect these headworks with the outside world. A novel feature of the telephone line is that it was built in conjunction with the pipe line, making use of steel bands that were rejected as not being suitable for use in the pipe line construction, but were entirely satisfactory for utilization in connection with the telephone line. These bands were attached to the pipe and projected up about 2 feet directly over the center of the pipe, where telephone insulators were fastened and the wires thus strung along the top of the pipe. Aside from making a very economical and satisfactory location for the telephone line, this resulted in protecting the pipe from being used as a pathway for pedestrians. Most of the pedestrians in that country are men going to and from the various timber operations, nearly all of whom wear heavily spiked boots and it is obvious that traffic of this kind on the top of an exposed wood pipe line would be very objectionable.

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[1] Discussion of this paper is requested and should be sent to the Editor.

[2] Consulting Engineer, Kansas City, Mo.

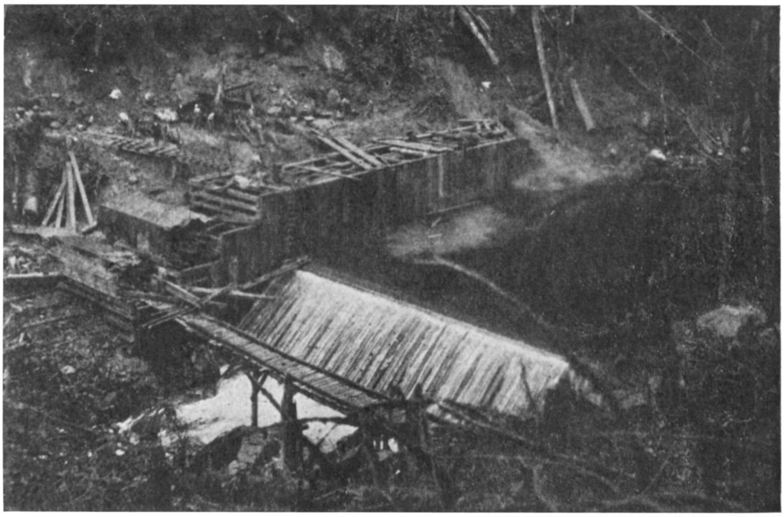

FIG. 1. CONSTRUCTION VIEW OF DAM AND BULKHEAD

The keeper has a well-built cottage and garden and there are cabins for the occasional visitors to the dam. The water passes through duplicate screens before entering the pipe line, and mechanical lifting devices have been provided to assist the keeper in cleaning these screens.

The pipe line from the dam has a capacity of 10,000,000 gallons per day. It comprises 101,838 feet of 28-inch wood stave pipe, 8,650.8 feet of 22-inch wood-stave pipe, 20,678.3 feet of 28-inch riveted steel pipe, and 576 feet of 30-inch cast iron subaqueous pipe at three stream crossings. This subaqueous work involved one crossing of the Snohomish River, a tidal stream 360 feet in width and water varying from 26 to 32 feet in depth, depending upon the stage of the tide. It also involved a similar crossing of a slough approximately 275 feet in width. This cast iron pipe was especially designed, weighing approximately 500 pounds per foot and provided with bell and socket joints. The subaqueous mains when tested were found to leak badly, and it was necessary to take them up and relay them. Even then one of them settled again, on account of poor foundations, and had to be repaired.

The contractors' failure to secure satisfactory work in the laying of these river crossings was due largely to the lack of proper equipment and lack of proper care in the alignment and grade of the trench prior to laying the pipe. The method used by the contractors was to lay the pipe from skids or barges, lowering one joint at a time and in many instances the pipe was over-deflected, which caused injury to the joints by squeezing out the lead ring, which it was found very difficult to recalk by divers at this depth of water.

After numerous attempts and efforts on the part of the contractors to secure a tight line, the engineers directed that the pipe line be entirely removed from the stream and relaid. This the contractors refused to do, and it was therefore necessary that the work be taken over by the city and completed under the direct supervision of the engineers, as provided for under the terms of the contract. The entire line of pipe was removed by direct pull of a donkey engine securely anchored 400 feet back from the river bank. A government snag boat was employed to hook onto the pipe near the middle of the Snohomish River section, and separate the line into two pieces by a direct upward pull at one of the ball joints. This was done with no injury to the pipe line other than breaking a small section out of the bell end of one section of pipe. This section of bell was successfully repaired by the oxy-acetylene welding process. The pipe line thus being divided into two sections was removed without difficulty by steel cables and a system of pulley blocks operating from the donkey engine.

The method adopted by the engineers for the relaying of this pipe was to build a skidway on the bank of the river, practically on a level, extending back for the full length of the pipe line, 360 feet. The pipe was put together and the joints thoroughly calked on this skidway. Provision was made at the river end of the skidway so that each joint would be deflected through the proper angle both ways, as the pipe was towed in place in the river bed. A bulkhead was built on the opposite side of the river of proper weight to withstand the pull in the launching of the pipe. When the pipe was fully completed on this skidway, a sufficient length of $\frac{3}{4}$ -inch steel cable was procured to operate the double system of pulley blocks so as to reduce the total pull to an amount within the capacity of the donkey engine. The skidway was greased and it was found that the starting pull was the most severe of any strain incurred during the operation of launching. Once the pipe started to move, it proceeded uniformly and uninterruptedly throughout its entire drag across the river bed. The entire operation of launching occupied about 15 minutes. The weight of the pipe line is approximately 90 tons. An effort was made to determine approximately the pull of the cable by determining the sag on the 800-foot span of cable between the donkey engine and the pulley block on the far side of the river. It was found, however, that the starting pull did not last long enough to quiet the cable so that this could be measured. At no time after the initial start did the stress on the cable appear to be more than one-half that induced by the initial pull.

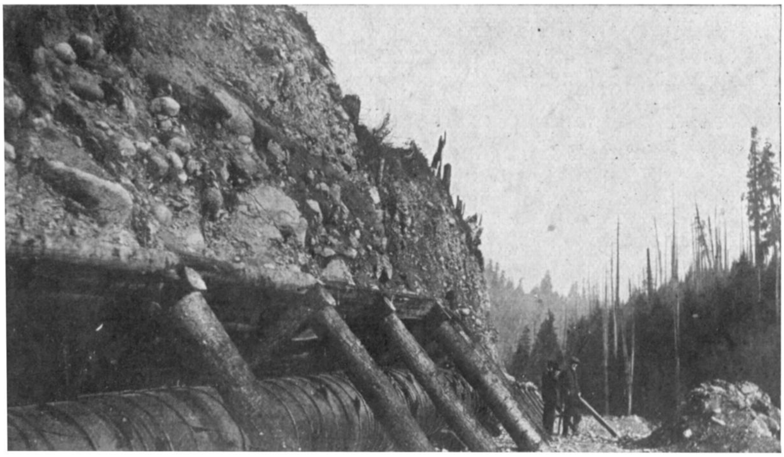

FIG. 2. PROTECTION OF WOOD STAVE PIPE

About half the wood pipe is buried and about half is exposed. The only reason for burying any of the pipe was on account of some sections of heavy virgin timber, which will undoubtedly be logged within the near future and it was thought that the only way to protect the pipe satisfactorily during the logging operations would be to have it buried. The conditions of the soil in this timber country are such that it is found that wood pipe has a much longer life exposed than when it is buried. There were 19,722 feet painted.

In securing the necessary grades and alignment, there were 93,927 cubic yards of earth excavation, 5,038 cubic yards of rock excavation, 1,289 feet of rock tunnels, 66 feet of earth tunnels, one steel and two wood bridges, 1,499 feet of timber trestle, 74 blow-offs and 57 air valves. About 2,000,000 feet, B. M., of stave lumber and 350,000 steel bands were used. The country crossed by the pipe line is quite rough in some sections and it has been occasionally necessary to protect the pipe as shown in figure 2.

The total cost of the new work has been $622,486, of which $45,760 was for rights-of-way and legal expenses and $64,719 for engineering services, including design and the supervision of construction. The supervising engineer was R. E. Koon of the engineering staff of Burns and McDonnell of Kansas City, Mo., who were the consulting engineers for the city.